

ACACIA
INFORMATION & COMMUNICATION
TECHNOLOGIES

The Sustainable Technology Loop Dimension

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Introduction

Within the numerous ACACIA activities in preparation of the detailed initiative plans currently under development by IDRC for submission to its Board of Governors, the need was felt to explore the technology question from a Canadian supply side. Having been on both sides of the demand/supply side and engaged in both development work and private enterprise, I was asked by the ACACIA team to provide that perspective in the broad spectrum that ACACIA represents. This paper looks at a technology model and its implications for the concepts and objectives set in ACACIA, summarizes sources of ICT supply, primarily in Canada, and submits a number of project ideas related to the conclusions drawn from the model under consideration. The proposed model was subject of a Round Table held in Toronto, Canada on June 26-27, 1997 in the wake of *Global Knowledge'97*. Several findings of that Round Table have been integrated into the paper.

A Technology Model

In the context of ACACIA technology must be considered within a broader definition that relates to the prerequisites, inputs, outputs and objectives of technology. The model proposed here is shown in Figure 1. It depicts a simplified technology creation and dissemination process within a country or a homogeneous region.

The simplification of the model is an attempt to isolate what I believe to be the primary elements that we should discuss and debate. Simplification was introduced by deliberately ignoring the multitude of horizontal interactions external to the model that normally exist at each layer, and grouping instead all external inputs relevant to the model in one entity.

The upper layer, ICT, and the related ICT applications, are currently the most visible part of the technology model. They are also the most fashionable one: the Internet, the Web, Tele-Medicine, Tele-Learning, Information Superhighway, DTH Satellite TV, etc. Its visibility is caused by their explosive growth, driven by global forces mainly in developed economies, as well as by the pervasive nature of the information underlying all ICT applications. The distinction between ICT and ICT applications is also deliberate. It is intended to illustrate my view that ICT for a country or a region is an *ultra-structure* representing the capacity and capabilities of that country or region in ICT, whereas ICT applications, including any physical information and communication infrastructure, are in essence an application of these capabilities.

The second layer, termed “feeder technologies”, are the fundamentals on which ICT is based and by which it is developed and evolved. It includes many branches of engineering (electronic, computer, telecommunications, power, process, mechanical, etc.), and applied sciences (material sciences, chemistry, physics etc.) as well as information sciences, financing, management and marketing, without which new technology cannot be produced and utilized. It is mainly this layer that uses, adapts and creates technology in the country or region in question. In the rapidly emerging global economy there is obviously increasingly strong interaction between the top layers of the

different countries and regions. As Sub-Saharan Africa (SSA) does not export significant ICT to other countries, Figure 1 shows this interaction as “External Inputs”.

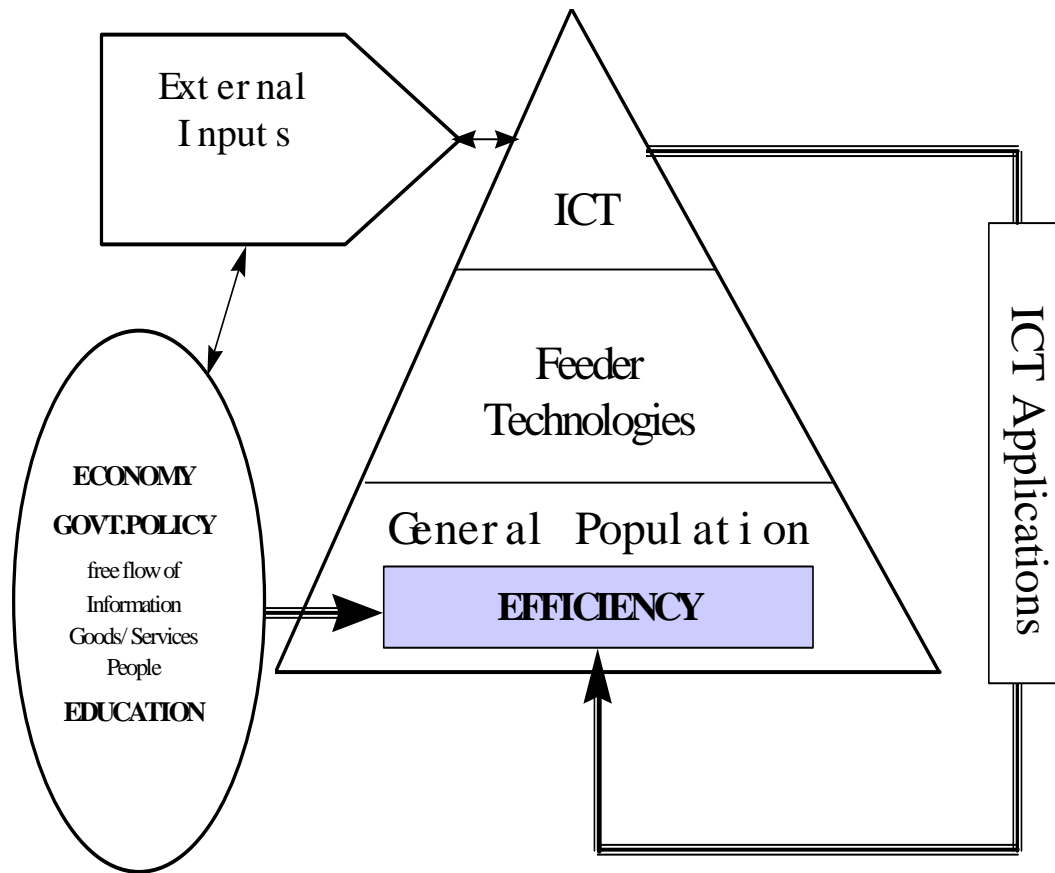


Figure 1

The third and most fundamental layer of the technology model is Layer III: a general population operating at a given *efficiency*. In the Round Table mentioned above, it was suggested that this *efficiency* layer itself is a process consisting of the elements shown in Figure 2. It was also suggested that the model link the “External Inputs” more directly to the controls of Efficiency, given that the ACACIA initiative supports policy reform in SSA and involves communities in the process. While these assumptions are true, it was felt, however, that the “External Inputs” did not dispose by itself of sufficient resources to bring the wide ranging changes needed to achieve significant changes in the Efficiency of broad masses. These “External Inputs” remain a catalyst aiming at initiating such change in the key elements controlling in more direct ways the Efficiency of broad masses of people.

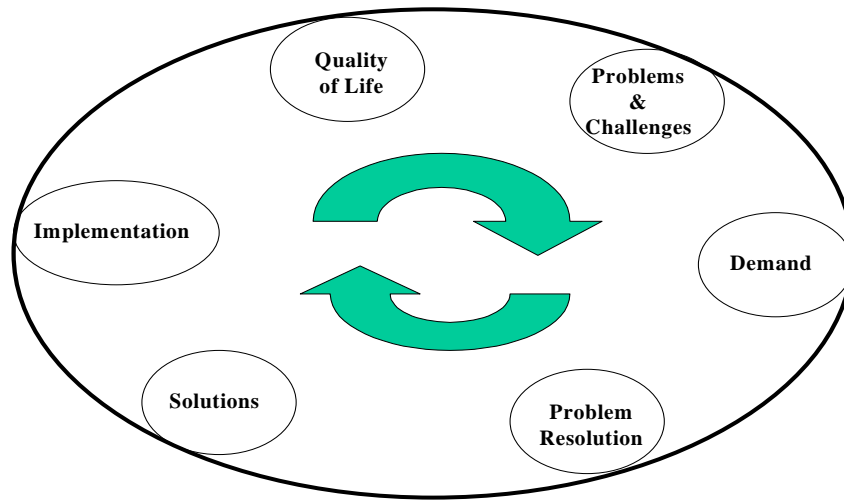


Figure 2

In essence it is the drive to increase efficiency and reap the benefits of such increase that dictates the development of technology in general and ICT in particular. Existing levels of technology and productivity in the country or region in question are only of secondary relevance in this respect. Regardless of the many names and designations used to describe such drive, it initiates immediately the process of using and developing technology, unless such drive is strongly inhibited. The result is a process of non-linear growth paralleling the increase in the value of technology in that economy. Countries exhibiting such a non-linear growth are given the name of “*emerging economies*” today, as only non-linear growth has a chance to reduce the gap between the linear growth of developed economies and the linear stagnation of so called *developing economies*.

The central role that ICT has taken in all economies can be more readily understood if we consider that ICT *applications* are the most comprehensive tools for efficiency improvement ever developed in the history of mankind. Because efficiency improvements in individuals, groups, organizations and society as a whole are directly related to the *quantity, quality and processing capacity* of information, and because ICT applications impact all three aspects significantly, ICT is the most pervasive mean to such improvements.

Figure 1 shows a flow from ICT to ICT applications, establishing a loop in the model and emphasizing the importance of the recursive nature of the model. Technology development and use in an economy takes place in cycles with a feedback that allows further development, use and wealth accumulation. It is a dynamic not a static process. External inputs may succeed in “jump-starting” the economy, but only maintaining and strengthening the “loop” can make the process self-sustaining. Disrupting the loop or

inhibiting its flow makes growth impossible regardless of the means engaged in each layer separately. This may provide a different perspective on the need for “integrated development”. Integration of development efforts should not be considered only horizontally (across sectors or development agencies) but also *vertically* across the entire loop of the model proposed. It should also be noted that the proposed model is applicable at several levels: regional, national as well as at the community level

One of the most interesting questions raised during the Round Table was the positioning of the ACACIA initiative within the proposed model. While some participants saw ACACIA conventionally linked to R&D in general and to the ICT Applications component, others reflected on whether ACACIA’s efforts should not be focused on the main catalysts and inhibitors of the flow in the loop. It is therefore of importance to consider these in more detail.

Although many measures of the loop’s flow could be arbitrarily chosen, *Efficiency*, taken in its broadest definition, appears to be the most suitable one. Its position in the fundamental Layer III enables it to better illustrate the linkage between that measure and some of the key factors influencing it:

Economy: is an essential component for the technological flow to take place. Although economy can be influenced by government policies, the latter are not the only determining factor driving economy (i.e. global recession hit most countries regardless of their government policies).

Government Policies: in particular regarding the free flow of

- information
- goods and services
- people

These three elements are particularly important to both the economy and to the process of technology creation and dissemination across the loop. In the few emerging economies we are witnessing, government policies leading to improvements in the free flow of these three elements played a major role in initiating and sustaining the “emergence” process so far.

Education: has multiple roles in the technology loop: it enables the use of ICT applications to achieve higher efficiency, it creates and maintains the second layer (feeder technologies), and it creates the demand and thus incentives and economic rewards for ICT applications. Most importantly, it could be the key to link the Efficiency requirements to the policies through the higher echelons of the community. Again, although education is closely related to government policies, it is a distinct category by itself. The countries of the former Eastern Block are an interesting illustration: regimes with strong educational systems and severe restrictions on the free flow of information, goods & services, and people, were still able to develop significant technologies in their areas of priority.

Depending on how the three elements cited above are applied they can be a catalyst or an inhibitor, making the efficiency layer in Figure 1 transparent and conducive to the flow or opaque and non permissive. It is no surprise to find that all three catalysts/inhibitors are in the domain of the public sector: introducing change at a large scale, particularly under the political realities of SSA, requires government participation. Discussions in the Round Table confirmed that ACACIA must operate within the existent policy frameworks. Further reflection on these key catalysts/inhibitors yields some interesting results.

The fact that the first key element, economy, is not solely determined by the policies of the region's governments leads to a number of conclusions. In recent years the development scene has been characterized (at least on the donor countries side) by a emphasis on "sustainable development" as opposed to "aid development". While sustainability must definitely be a core development objective, this emphasis reflected much more the desire of the donors to reduce their contributions to development and redirect some of these contributions to domestic issues. Regions of the developed world that are hit by disasters (California earthquake, Quebec's flooding etc.) are immediately granted aid. The underdevelopment of the SSA is a regional disaster of unimaginable scale and suffering, and the development process of SSA must hence continue to include a substantial "aid" component on the road to sustainable development. Such conclusion has direct implications not only for the rules and regulations for the supply of technologies to the area, but also for the change that must be achieved in the key catalysts/inhibitors of the technological loop. If these key elements are mainly in the domain of SSA governments, then the governments of the developed world and not just its development agencies must play a stronger role in bringing about these changes.

Similarly, if government policies are strongly inhibiting the free flows required for the technology loop to exist and grow, then there is little benefit from investing in any of the different layers. It is more effective to remove or reduce the inhibitors of the loop, allowing the process to sustain itself. There are rarely guarantees for any process to be sustainable, but such self-initialized technology loop, in the view of many, comes closest to any such guarantee.

Education as a key catalyst/inhibitor at the base layer must be considered differently from education within the context of the higher layers of ICT and feeder technologies. The education that will start the technological loop process or amplify it need not necessarily be ICT related. In a specific environment it has only to create and strongly disseminate sufficient knowledge about that environment and about ways to improve efficiency within its set of constraints. Disseminating on a large scale knowledge about water purification, agricultural techniques, healthcare, and local market needs in SSA, and improving literacy and "numeracy" for example is more important for the purpose of a sustainable technology loop than knowledge about the web etc.

Improving the level of education at the base layer not only leads to initiating and strengthening the technology loop, but this loop process is the common root to the development and flourishing of all technologies in the region of interest. While the focus

of the ACACIA initiative is specifically ICT, these do not exist in a void, but rather as part of the broad technology “ultra-structure” that every country and region requires in order to be viable and competitive. Developing ICT cannot succeed in isolation from other technologies within an economy.

External Inputs - Supplying Appropriate Technologies

Having submitted the model, it becomes obvious that the external inputs aiming at bringing change to the three key elements influencing the “opacity” of the general population’s efficiency to be the primary and most effective inputs at this stage. But external inputs need not be limited to this primary group. In fact the resources needed to provide that particular group of inputs is quite different and independent from the resources currently engaged in the development effort worldwide.

For consistency we should again consider any other inputs from the point of view of their contribution to:

- Increasing the efficiency of the general population
- Creating and strengthening all layers of the technology loop process
- Improving the free flow of information, goods, services, and people.

Consequently, external inputs should focus on supplying technology appropriate for the above objectives. Just because specific ICT or applications have proven efficient in a developed environment does not necessarily mean they are equally efficient in a developing environment. To take the example of the large scale dissemination of information on water purification, agricultural techniques, healthcare, and local market needs in SSA mentioned earlier, such task is not necessarily best achieved by computerized kiosk browsing the Internet. It can be argued that it could be done much more effectively through small portable radio receivers that can tune in to community radio stations broadcasting in the local language.

In the seventies there were attempts by some developed countries to define “appropriate” as equal to “obsolete” and use the concept to dump their surplus technological products into developing countries at exorbitant prices. In the past two decades, however, we have seen the concept of obsolescence in developed economies move from purely physical to a so-called “virtual obsolescence” definition. In the fifties and sixties obsolescence was determined by a degree of tear and wear making the product unusable. It is today defined as that point in time when the efficiency of the current product (i.e. productivity revenues less costs of operation & maintenance) becomes less than that of the next generation of the product. This is most visible in the dynamic industries of the developed economies: fully functional mainframe computers would be replaced with the next generation of mini-computers or client-server micro-computer architectures; fully operational military aircrafts would be retired and replaced with newer generation. The reason behind this phenomenon is the rapid strides in technology that made operational costs of the newest generation significantly less than the previous generation, and such improvement is a relevant competitive advantage.

Overall efficiency of a product, however, is usually very dependent on the operational environment: value of competitive advantage, quality and cost of human resources required, cost and access to spare parts, etc., all of which differ substantially between developed and developing countries. What is “virtually” obsolete in a capital-intensive high-labor-cost environment *can* be an efficient solution in a capital-weak low-labor-cost environment. Such appropriate technology must hence be judged on its merit for the improvement of efficiency of the developing environment, not on its potential to reduce cost of virtual obsolescence to the developed environment.

More importantly, appropriate technology for developing economies is not necessarily best defined as the virtually obsolete technology of developed economies. On the contrary, appropriate technology could, and indeed should, be created to respond specifically to the needs of developing environments. A brief look at how technology is applied to the needs of developed countries might help understand why such new appropriate technology is not being produced in the developing world.

- First a market need is identified.
- Next a product or service that could fulfill that need is defined and its characteristics specified.
- Then the opportunity related to such fulfillment is qualified in terms of required investments, projected cost of marketing, selling, and supporting the product/service, and finally the projected returns on these investments.
- Only when such return is perceived as efficient, is the process starting with the investments and leading to the required product/service is initiated.

The difficulty to develop new appropriate technology for SSA starts with the lack of a clear definition of market needs, that results in weakening the entire sequence of events that should follow. Market research is undertaken mainly in response to major technology supply interests from developed countries (i.e. telecommunications, manufacturing plants etc.) and even when this is not the case the process is usually driven by a business model developed outside the region and not necessarily applicable to it. Estimating demand for telephone service for example using models based on assumptions and utilization patterns valid in the industrialized and urbanized environments of developed economies, might not be the most appropriate way to forecast telephone service demand in agrarian rural developing economies.

A Summary of the Needs

While many research activities investigate the demand side, this section focuses on needs in terms of major necessary and desirable technological capabilities as identified by the Round Table participants beyond the conventional Internet and Web technologies.

- Packaging the information for the communities of concern in ACACIA is a central issue. It involves a national language interface as well as strong verbal bias in order

to accommodate illiterate users. It is felt that a focus on new radio broadcasting technologies and the development of new interfaces (verbal, tactile etc.) is needed in order to communicate information content successfully to these communities.

- In the area of national resources management there is a need for innovative repackaging techniques allowing the efficient communication of related information (weather maps, remote sensing data etc.) to the concerned communities in understandable and practically useful ways.
- Current hardware platforms have been developed for the environments of industrialized countries. There is need for affordable, rugged and reliable hardware requiring minimal or no maintenance, that can be deployed efficiently in SSA.
- There is an urgent need to increase local maintenance and support capabilities for the currently installed base of equipment, including enhanced capacity for simple and inexpensive remote diagnostics tools capable of operating over low-speed links.
- Information needed for developing curricula and teaching ICT at all levels is needed across the continent. The model of “regional centers” has not been very successful and there is a need to develop new more efficient mechanisms for cross-sharing knowledge and technological experience between communities, and for making technology friendlier.
- Special attention should be given in the technological needs of rural areas (i.e. preferred technologies for coverage of rural areas etc.). So far most of the ICT development efforts have been towards urban centers.
- There is need for new innovative ways for financing technological solutions in general and ICT solutions in particular, drawing on the capacities of both private and public sectors. Such financing must be better adapted to the needs and requirements of small and medium enterprises in SSA.
- Application of technology to development should not be limited to new technologies. Conventional and new technologies must be used for solving problems and responding to the needs of the concerned communities according to availability and practicality.
- There is need to develop the regional, national and local capacities in formulating their needs not so much in terms of development aid and programs but rather in terms of markets, demand and corresponding potential for profitable supply. Such new definition of needs would support more economically sound capacity development, increased investments, and commercial supply by local and/or foreign sources.

Sources of Supply in Canada

It would be obviously impossible to conduct an exhaustive survey of all ICT supply sources in Canada within the framework of this assignment. Canada has strong ICT capabilities and intricate ICT-based industries. This section provides samples that illustrate the scope of supply that Canada can offer in ICT.

Telecommunications

Canada has a long tradition in pioneering telecommunications products and services. It was the first country to established through the Canadian satellite Anik-1 a satellite-based domestic telecommunications system that addressed the issues of “thin-traffic” regions, where population density is relatively low and dispersed across a large geographic territory. It is home to **NORTEL** (formerly Northern Telecom) one of the world largest suppliers of telecommunications equipment, and to **MITEL** one of the largest PBX manufacturers in the world. Through its **TELEGLOBE/STENTOR** group it has significant capabilities in implementing major telecommunications infrastructure projects including ships for laying under-sea fiber-optic cables. The Canadian-based **BCI** has substantial telecommunications networks management expertise and has managed the national network of foreign countries. **TELESAT CANADA** has interesting solutions for Internet connectivity through satellite: its DirectPC solution that includes a satellite dish and an interface card are offered at \$595; it is offering two competitive packages: the MoonSurfer which offers unlimited 400 Kbps satellite download access from 6p.m. to 6a.m. weekdays and all day weekends for \$54.95 per month; and the SunSurfer offering unlimited daytime access for \$179.95 per month.

Software Industry

Canada is well known for its software industry that exceeds 10,000 companies, ranking in 1993 as 5th in the world ahead of the United States (7th). A quick review of some world known names illustrates this capacity:

- **Alias:** one of the first and largest computer animation companies in the world acquired recently by Silicon Graphics Inc. (<http://aw.sgi.com>);
- **Carp Systems:** world known for their manufacturing planning software (Tel: 613-728-8200);
- **Corel:** developer of CorelDraw, and now owner of Wordperfect and CorelSuite (<http://www.corel.com>);
- **Delrina:** makers of Winfax & Wincomm, recently acquired by Symantec (<http://www.delrina.com>);
- **Discreet Logic:** specialized in morphing and computer graphics (<http://www.discreet.com>);
- **ISG Technologies:** providers of world leading surgical navigation and medical imaging software (<http://www.getafix.isgtec.com>);
- **Knowledge House:** providers of patient simulator software (Tel: 902-434-1814);
- **Modatech Systems:** well known for their sales automation, contact management tools and computer / telephony integration (CTI) solutions (<http://www.modatech.com>);

- **MedcomSoft:** world leading systems for community health information networks (Email: amcs@medcomsoft.com);
- **Softkey:** suppliers of low-cost quality software solutions (<http://www.softkey.com/canada.html>);
- **QNX Software Systems:** makers of the QNX real-time operating system (<http://www.qnx.com>);
- **Rascom Ventures:** software for retail brokerage (<http://www.rescom.com>);
- **SSA Inc.:** object-based enterprise resource planning (<http://www.ssai.com>);
- **TGS Systems:** makers of world class programming tools ;
- **Worthington Software:** offering an interesting solution to capture data on paper forms through standard fax machines directly into computers;

Internet

- **ALIS Technology:** suppliers of bilingual and multilingual computer peripherals and browsers (<http://www.alis.com>);
- **Microplex Systems:** maker of the NetEye, the cheapest way to connect a video camera to the net (<http://www.microplex.com>);
- **Milkyway Networks:** Firewalls, X500 directories, X509 certificates (<http://www.milkyway.com>);
- **Open Text:** a Waterloo University spin-off with an extremely performant search and indexing engine (<http://www.opentext.com>);
- **PointCast Canada:** award-winning user customizable Internet publishing offering with the Globe & Mail, Boston Globe and L.A. Times (<http://www.pointcast.ca>);

Systems & Hardware

- **AIT:** machine readable documents including passports, and readers at major world airports(<http://www.ait.ca>);
- **ATI:** well known for their graphics adapters and controllers (<http://www.atitech.ca>);
- **BYTE:** suppliers of integrated (electronic and non-electronic) document management solutions with the innovative composite folder concept (<http://www.bytequest.com>.;);
- **DEVELCON:** suppliers of LAN/WAN internetworking for ISDN, Frame Relay, X25 and leased lines; acquired in 1996 EDA (see below), (<http://www.develcon.com>)
- **EDA:** Low cost data switching solutions including packet switching (Chile, Federal Express Europe etc.); merged with Develcon;
- **Gandalf:** (currently being acquired by Mitel) Enterprise data switching solutions, small ISDN routers (<http://www.gandalf.ca>);
- **M3I:** Large color display systems;

- **Newbridge:** a well known success story in data switching solutions (<http://www.newbridge.com>);
- **Oasis Technologies:** transactional switching and applications serving all major credit cards worldwide and automating banks in China (<http://www.oasistech.com>);
- **PenMagic Software:** developers of the pen-based operating system (Email: penmagic.com);
- **Samtack Computer:** 3D graphics/video accelerators, video output to TV screens both PAL & NTSC (<http://www.sicem.com/p-samtac.htm>);
- **Systems Xcellence:** transactional networks for healthware and electronic commerce applications (<http://www.jobsat.com/sx.htm>);
- **T-Base R&D :** provider of leading-edge solutions using smart cards for controlling access to computer and network resources;
- **Wildcard Technologies:** integrated messaging platforms, including computer/telephony software, fax server boards and speech recognition (<http://www.wildcardtech.com>);

Electronic Manufacturing

- **Iotek Inc.:** designer and manufacturer of Digital Signal Processing (DSP) chips;
- **Vemco Ultrasonics:** designer and manufacturer of Digital Signal Processing (DSP) chips;
- **Celestica:** a former IBM company, provides electronic manufacturing services to third parties (<http://www.celestica.com>);

Educational & Distance-Learning Systems

- **Collège de l'Acadie:** providing community college courses through interactive connection to remote students (<http://www.acadiau.ca>);
- **Lapro.com:** multi-media educational systems (Tel: 604-231-1628);
- **Waterloo Maple Software:** world leading symbolic mathematics educational software (<http://www.maplesoft.com>);

The above merely scratches at the surface of a broad and vibrant industry, one whose multi-cultural environment makes it sensitive to development and generally willing to contribute to it. There are several resources to identify more selectively Canadian suppliers for a particular product or service:

- Web site of the **Strategis** system of the Federal Government's Industry Canada (<http://www.strategis.ic.gc.ca>);

- **WinExport** of the Federal Government's Foreign Affairs & International Trade Canada (<http://www.dfait-maeci.gc.ca/english/trade/winexp.htm>);

Research & Development Trends

This section describes briefly the major trends of ICT key categories:

Processing Power:

Moore's 1965 law stating that transistor density in microprocessors will double every two years appears to be still holding. This technology is still largely dominated by Intel processor architecture. The Pentium Pro is moving rapidly to become the mainstream processor for servers, high-end workstations and multi-processor systems. Desktop systems with the new Pentium II chip are already being offered. Intel has already prototypes running at 300-333 MHz using 0.25 μ technology. Progress is expected to continue unabated in this field as can be seen from the series of new processor code names at Intel: Klamath (first half 1997), Deschutes (first half of 1998), Katmai (mid 1998), Willamette (late 1998) and Merced (1999).

A subtle but potentially strategic change is occurring in the instructions set of the Intel processors. For the first time since the introduction of the Intel 80386 processor, Intel has introduced change to the instructions set of its main line of processors, adding about 57 new instructions, some of which allow single instruction/multiple data manipulation. The changes are designated as MMX technology. Taken together with the fact that Intel is developing with Hewlett-Packard a new 64-bit instruction set called IA-64 expected to debut with the Merced processor in 1999, this could mean the end of the x86 architecture and a further step closer to the RISC architectures.

Intel is facing increased competition from AMD and Cyrix both of which have competing processors supporting both 32-bit and MMX, and some of which have proven faster than current Pentium Pro processors. One of the areas Intel's competitors are targeting is the low-end configuration (less than \$1000 machine) where their price advantage becomes significant to integrators. Such pricing could change substantially some of the assumptions underlying recent ACACIA papers related to the supply side of ICT.

The RISC processor field is still splintered among the main suppliers (DEC's Alpha, SGI's MIPS, IBM's R/6000, HP's PA-8200 and Motorola's PowerPC). RISC processors are still used mainly in high-end workstations and have not captured a significant share of the desktop computer market. They have a better penetration in the server market but are still facing stiff competition from multiple Intel-processor platforms. Towards the end of this year the performance leader is expected to be DEC's Alpha 21264 debuting at 500 MHz and using a 64-bit system bus operating faster than 300 MHz.

In general, industry projections expect a processor performance of 50,000 MIPS by the year 2000 and about 100,000 MIPS by the year 2011 (based on 10 GHz speed and 0.07 μ technology). The consequences of such projections for ACACIA are substantial: the processing power that will be available before the year 2000 already makes it possible to implement applications such as continuous speech recognition or handwriting recognition, that until recently appeared impossible or unaffordable for developing environments.

Memory:

The standard memory size for a “home” computer has climbed to 16MB, while that of a “business” computer is nearing 32 MB. Preparations are underway by major manufacturers to gradually phase out of 16MB chips as the 64MB chip is ready to go to production, followed not too far by the 256MB chip. Global supply is still abundant so prices of current main stream models (72-pin, 32-bit SIMMs) are not expected to rise. It is likely, however, that new models will be introduced that will replace the current mainstream: DIMMs (for Dual In-line Memory Module) using synchronous or Rambus dynamic RAM (SDRAM and RDRAM respectively).

System Architecture:

The PCI internal bus has become standard replacing previous local-bus architectures (VLB) and appearing even on newer Power Macs ! The new Intel ATX motherboard design allows for improved heat dissipation and indicates the continuing shift towards a new systems architecture. Graphics adapters will be moving to the new Accelerated Graphics Port (AGP) standard for a more direct connection between the processor and the adapter. The emerging Unified Memory Architecture (UMA) will simplify further system design allowing computer subsystems like the video card to draw on the system’s single memory bank. The first Universal Serial Port (USB) have appeared already on new motherboards and systems, even though there are not many peripherals to attach to it. The USB offers a simple way to connect all sorts of devices ranging from keyboard and mouse to scanners, printers, modems and digital speakers at a higher speed of 12 Mbps (as compared to the current 115 Kbps of the serial ports). The USB is expected to be overtaken by the proposed IEEE 1394 standard, also known as FireWire, which would allow a speed of 100 Mbps and the connection of next generation hard drives and video input devices.

More importantly Microsoft and Intel are engaged in a definition of the specifications for a “zero-maintenance PC” and “zero-administration Windows”. The system envisaged would have intelligent hardware and software and a self-updating operating system.. Although still at an early stage, such a system if coupled with high system and components reliability could improve the effectiveness of IT in under-developed areas where maintenance and technical support may be not available or easily accessible.

Storage:

The cost per Megabyte of storage has been as steadily declining as the density of storage has increased. From the humble beginnings 40 years ago at 2 kilobits per square inch and \$10,000 per megabyte, storage has come a long way to reach today's 1.4 gigabits per square inch at 10-15 cents per megabyte. The most recent changes have been brought by the move from thin-film inductive to magneto-resistive heads. Densities of 5 gigabits per square inch have been already achieved in the laboratory and industry projections call for the drive capacity to grow three- to fivefold over the next 2 years, and up to tenfold by 2002. Prices are expected to fall to 3 cents per megabyte by 2000. Beyond the 5 gigabits density it is expected that spin-valve heads technology will take over up to a density of about 10 gigabits. The higher density allows more data to be read at the same rotational speed; nevertheless rotational speed is increasing rapidly from the current 4500-5400 rpm to 7200 and even 10000 rpm.

Interfaces must evolve accordingly to avoid becoming a bottleneck. Enhancements to both the EIDE and SCSI standard are continuing, offering up to 40 MB/sec on the latter. Other interfaces are competing to replace the highest SCSI interface: Fiber Channel, IEEE 1394 (FireWire), Serial Storage Architecture (SSA!) etc. It is expected that at least the high-end storage devices will be replaced by FireWire-compatible devices as they become available.

The speed of the standard CD-ROM drive is continuing to increase rapidly with 16X drives appearing recently. The CD-R (recordable CD-ROM) is coming closer to user needs through a new technology called Packet Writing CD-R that allows the recording of only a portion of the CD-R media similar to a floppy diskette. In the meanwhile other removable storage devices are appearing that can support between 120MB (LD-120 diskette drive of Compaq) and 1.2 GB (Iomega's Jazz drive).

Magneto-optical storage device are bringing the more dramatic change in 1997: the Digital Video Drives (DVD) will support *initially* 4.7 GB *per side* read-only storage in a form factor similar to today's CD-ROM, and will support later 8.5 GB per side with dual layers. DVD-RAM (writable versions of the DVD) devices supporting 2.6 GB using phase-change technology are expected for early 1998. It is anticipated that next versions of DVD-RAM will support 6-7 GB using magneto optical MO7 technology and the 120mm format of CDs and DVDs. A smaller DVD-RAM based on 8cm-format is already defined aiming at better portability.

Tape technology has also evolved accordingly to match the capacities of the on-line storage devices. The developments are mainly in the move to magneto-resistive heads, servo tracks (extra tracks that help find data tracks), eight-channel heads (vs. One-channel today) and digital channels. Digital Audio Technology (DAT) tapes are capable now to store over 13 GB of data on a minuscule 8 mm tape cassette. Several developments are pointing towards tape systems that behave as a "random access" device

(i.e. hard drive). Industry projections expect an *optical* tape drive within the next 5-10 years. Not too far behind is the intriguing new technology of holographic storage, which promises volumetric (vs. Areal) densities in terabits !

An interesting new storage device is Intel's Miniature Card or MC, supported by 10 other manufacturers. It is intended to bridge digital cameras and recorders with computers. Initially offered in 2 and 4 MB cards, but soon to be available in 8 and 16 MB cards, the MC specification allows up to 64MB. It can be inserted into a PC Card adapter and plugged into any notebooks PC Card slot. It appears to the computer as an additional drive, whose files can be manipulated in the usual way. MC-based solutions include digital camera pictures, recorders, cellular phones, web TVs, global positioning systems (GPS), hand-held PCs and hand-held games. There are one or two other competing formats of the same nature. Whichever proves to be the winner, there may be interesting applications for this technology in developing environments.

Display

Liquid Crystal Display (LCD) technology is coming of age. Color LCD panels with 1024x768 pixels resolution are being used in high-end notebooks, and higher resolutions (1280x1024 @ 157 dpi) are already on the horizon. LCD panels of up to 20" have been demonstrated. For display panel sizes larger than 20 inches the gas-plasma technology appears to have more potential. Several manufacturers have shown prototypes of 40" gas-plasma displays ready for production. Digital TV standards, long contended by competing industries appear to be finally ready for approval by the FCC in the U.S., which would unleash the many applications anticipate for this technology. Supporting resolutions of up to 1920x1080 pixels the new standard would work well with both data displays and digitized video. Gambling on the possible economy of scale resulting from the convergence of the display of computers and HDTV several large manufacturers are already offering wide-aspect displays following the 16:9 ratio screen of the HDTV standards (as opposed to 4:3 of current CRTs).

Several other technologies are awaiting either large scale acceptance or further refinements. The former is exemplified by Texas Instruments' DLP technology, which uses microscopic mirrors directly on a chip to deflect light, and which is finding applications mainly in projection systems. The most promising of the latter group appears to be FED panels which is expected to be fielded in notebooks and palmtops by 1998.

In summary, the new display technologies will be able to provide thinner, lighter and less power consuming displays, but their cost is still prohibitive, except may be the larger (public) panels, whose cost could be justified by the large number of viewers benefiting from it. ACACIA must monitor which technology finds broadest acceptance, as this is the one that most probably will become affordable.

Operating Systems

This segment is divided in desktop OS and network operating systems (NOS). The former is dominated by Microsoft DOS/Windows 3.x and Windows 95, soon to be followed by Windows 97. In the corporate world a minor share is held by Microsoft's Windows NT Workstation 3.51 and 4.0 and by IBM's OS/2. Microsoft's plans call for a single Windows operating system by the year 2000, which obviously will be based on the evolution of NT.

The NOS arena has three main contenders: Novell's Netware, Microsoft's Windows NT Server, and the group of Unix operating systems represented mainly by Sun Microsystems, SCO, DEC, HP etc. DEC's Digital Unix is the only OS to support 64-bit operations so far, but several other suppliers including HP are developing 64-bit versions. The current battle is between Windows NT and Netware at the low and medium size networks, and NT appears to be increasing its market share slowly. Microsoft has licensed DEC's clustering technology and is actively developing an NT Cluster, which was to be released in the spring of 1997, but will be delayed at least to the summer. Once the NT Cluster is released it will contend with Unix for the larger systems and networks.

Networking & Communications

The mainstream technology for local area networks (LAN) has decisively moved to 100 Mbps technology, and with the increased volumes the pricing for 100 Mbps devices is coming down substantially. Work is already underway for the so-called "Gigabit" Ethernet. On the Wide Area Network (WAN) side both Frame Relay and ATM applications are penetrating the market slowly.

On the local loop side, ISDN although currently the only practical choice for a digital connection on existing telephone wiring between the user site and the nearest point of presence, is threatened by new technologies. ISDN pricing has prohibited so far a larger utilization and opened the door to competition from other technologies, both digital and analog. The primary candidate is Asymmetric Digital Subscriber Line (ASDL) that is currently being demonstrated in the U.S. and Canada. On the analog side, modem manufacturer U.S. Robotics has developed a new modem speed-doubling technology called 2X, which can support 56 Kbps on a telephone dial-up line, provided that intermediary equipment (such as PBX) does not cap performance. The 2X technology is the core of a new CCITT proposed standard, which, if approved, will make it possible to use this technology between the modems of different suppliers, and thus enable wide scale use of this technology. What is less known is that this technology assumes digital links between the ISP and the telephone company to achieve the higher speed on the down-link. While such digital links are common place in developed countries they are often an exception in developing regions.

Interestingly, while the envelope of the local loop's bandwidth is pushed higher, other technologies are bringing the requirements for transmission of multi-media information

lower. An example is a technology developed by Vxtreme Inc. in the USA that allows the transmission of audio and near TV quality video over 28.8 Kbps lines.

Software

It is not possible to cover in any detail the development of software within the scope of this report. “ Nearly everything about programming has changed in the past 15 years – the operating environments, the languages, the paradigms, and the systems themselves.”[38] However, a few trends appear to have considerable significance for the development process. Briefly, software has significantly increased in terms of complexity, application size and operating platform requirements. Although applications are more robust, feature rich and user friendly these developments only mask substantially higher complexity hidden underneath the surface. From a sustainable technology loop perspective this means that while users will be able to utilize some of these applications better, those who are to support these applications technically and maintain them are in a worse situation. The users themselves are not much better off as their existing systems are obsolete rapidly by the higher requirements of applications and their economies make replacement of such systems much more difficult than in developed economies.

These trends are continuing rapidly producing new categories of software: autonomous agentware, which can learn the users habits and preferences and deliver personalized content; new technologies like *collaborative and adaptive filtering* are being rapidly added to enhance the capabilities. Distributed computing is moving rapidly from the familiar remote file systems to more recent distributed objects and very soon to moving objects. Transaction based applications are finally coming out of the proprietary silos and moving into mainstream applications. The evolution and convergence of the different directory services on LAN, WAN and Internet is creating a new area of communications software programming. These trends threaten to obsolete the capabilities of the educational systems of developing countries.

At the same time there are other developments that could partially offset some of these trends. The most important of these may be the Network Computer (NC) paradigm. If this paradigm becomes dominant it may force applications to downsize their program size and platform requirements in order to be easily downloadable to the NC. Both the NC and the Java cross-platform development language are still driven by market economies of the developed countries. This paradigm is worth investigating, however, for the purpose of determining if and how it could be developed differently to serve large scale low-cost deployment of ICT applications in developing environments.

Proposed Research, Development, & Pilot Projects

In order to initiate the creation of new appropriate technology the shortcomings of the current process as described on page 6 must be remedied. If a process can be found by which we can contribute to:

- defining the needs (not in ICT or information but in the most broadly needed and desired tools to improve the general population's current living conditions),
- spurring innovative thinking on specific new products and on services responding to these needs,
- and assisting in qualifying the opportunity of fulfilling these needs,

there would be no shortage of external investments to develop, produce and supply these products and services, because they are profitable. Profitable development is a sustainable development.

IDRC is uniquely positioned to attempt to devise such process. It has long-standing relation and privileged access to two key players in this scenario: the NGOs and the indigenous R&D capacity. Who better than the NGOs representing grassroots movements to help articulate the real needs? And who better than the indigenous researchers, scientists, engineers and technicians to come up with innovative ideas for products and services that can fulfill the needs successfully within the economic and cultural context they understand much better than any external expert or consultant. The role of IDRC would be in establishing the framework and support for this endeavor, and linking it with appropriate external sources of supply.

Research of needs as described above should not be limited to the broad masses. As discussed earlier any large-scale change will have to involve the government and the public sector. If these are not to become a bottleneck in any of the development processes their efficiency must as well be improved. Improvements to the public sector performance have been attempted through "institutional capacity building" projects, which more often than not copied processes, business models, and ICT from developed countries into these public sectors. Success has been somewhat mixed. What is often overseen is that the existing processes and bureaucracies, as inefficient as they may appear, reflect deeper a certain distribution of *power* specific to each country. Power distribution in an economy is always complex and deeply rooted in the social, economic, political and cultural heritage of the country. Imported models - willingly or unwillingly - change the pre-existing power distribution, and often trigger therefore responses that threaten and even reverse the benefits anticipated from these models in the first place.

The SSA is politically fragmented and encompasses a wide political spectrum. No single model can provide the optimal solution for all or even the majority of existing public sectors. There is hence a need to research and find the appropriate model for each country that can bring the needed efficiency improvement in the public sector, taking into consideration the underlying power distribution. Again, such research effort can only be carried out by indigenous capacity with some external support.

Furthermore, both public and private sectors in developing economies have usually difficulties finding the necessary resources for the capital investments required for establishing their infrastructure (ICT or other). There is need to develop new *business models* for the funding of such infrastructure projects, or to investigate some of the recent models that are being proposed in some emerging economies (i.e. Philippine Health Community Information Network), and possibly adapt these to developing environments.

Finally, it may be worthwhile to explore the possibility of negotiating a special “development” pricing for ICT products, similar to the special “educational” pricing granted to all institutions of learning in the developed countries. Such concept would require a coalition of development agencies to establish a clear and practical definition of the countries and type of projects that would be eligible for this special pricing. A mechanism to exit the system once the economy has reached certain well-defined levels (measured for example by GDP per capita) must also be devised. With such definition in place, major suppliers could be approached and brought on board. Such category of pricing would allow available development funds to go further, increase affordability of ICT products and services for the target population, and probably reduce to an extent software piracy.

Specific Projects

- **Defining the appropriate systems platform for developing environments:** this project should investigate the application of available technologies to the design and manufacturing of affordable rugged computer platforms for the SSA region. The features of such platform would include possibly built-in UPS with low-cost common battery elements, improved heat and dust resistance, rugged keyboard and pointing devices and swappable large-capacity storage media.
- **Generic voice applications:** The project would focus on establishing local capacity for developing and supporting applications including both telephone-based and computer-based automated voice response systems, telephone-based retrieval of recorded thematic information, synthesized voice output for web documents, etc.
- **Unicode-based Applications:** The project would focus on developing local capacity for the development of commissioned Unicode-compliant applications or the migration of selected applications from freeware/shareware to Unicode-based versions supporting a host of national languages without the need to modify or customize the application for every different language. These applications would strongly support the wide deployment of important applications, including the voice-based applications described in the previous paragraph.
- **Strategies and technologies for low-cost sharing of scarce ICT resources:** this project would focus on exploring, evaluating and recommending viable solutions for sharing scarce ICT resources. In particular, the project will evaluate emerging technologies such as NetPC technologies, Microsoft's Zero Administration Kit (ZAK) and the Windows Terminal concept for the specific purpose of reducing the overall

deployment and ownership cost in SSA, primarily in schools, universities and public administrations.

- **Methodology for developing locally adapted ICT business models in SSA:** The objective of this project is to provide both public sector organizations and private small and medium enterprise in the region with a practical easy-to-use business model for planning and evaluating the impact of ICT on their core businesses. Such tool would help gain insight into the full cost of ICT deployment as well as the real benefits from such deployment. It would be invaluable in guiding the efforts of introducing ICT into the region in an economically viable and self-sustaining way, as well as in attracting external investments.
- **Cooperative financing models for ICT applications in developing environments:** using experience gathered from other parts of the world, this project would demonstrate how to search for, find, and evaluate innovative financing solutions for major ICT projects, involving true cooperation between the public and the private sectors. The project must be limited to a large-scale project in a specific country and illustrate how solutions can be adapted to the specific conditions of the country and sector in question. The purpose is to provide public administrations with affordable solutions to implementing major ICT undertakings, which are currently not possible due to unavailable financing by the government.
- **Needs of SSA communities:** This group of projects would concentrate on identifying those community needs that lend themselves best for ICT support. The focus would be on identifying the community needs in general, and those of small and micro enterprise in particular, rather than on the “ICT” needs. Activities would be carried out mainly by local capabilities. The purpose is to support the self-sustaining technology loop in the communities rather than injecting ICT in any possible way. Only such loop will lead to a long-term demand and useful harnessing of ICT.

Canadian African Alliances

Canada has been a pioneer in the area of telecommunications for “thin traffic” areas. This includes terrestrial and space-based systems that have been developed and deployed into the northern parts of Canada. Creating an alliance between the Canadian organizations that fall under this pioneer category and organizations seeking innovative ways to establish a blue print for African telecommunications (for example Telecom Africa, RASCOM etc.) would be useful for a more systematic transfer of the acquired experience into the design process of such blue print.

The rapid deployment of reliable telecommunications and information infrastructure in under-developed areas has much in common with tactical military communications deployments. With the general reduction in defense budgets and military personnel numbers, both the armed services and the defense industry are seeking alternate uses of their knowledge, capabilities, and products. Involving the services and the defense industry in alliances and joint projects aiming at deploying unconventional

telecommunications and information infrastructures such as HF data networks, VSAT voice-data networks or Spread-Spectrum Wireless Networks would feed valuable expertise and knowledge into the concerned alliances and projects.

An alliance between ITAC and similar organizations in the SSA region is much needed. It would create programs and mechanisms to support joint undertakings between Canadian and African private enterprises. It would assist in identifying opportunities and developing sound business plans for new ICT-based products and services, and would broker suitable financing for promising plans.

A first step towards fostering such alliances would be for ACACIA to identify more precisely programs and projects that support its objectives. This may include projects that ACACIA is sponsoring, endorsing, or seeking to launch on its own. Once this is done, the next step would be to identify in detail organizations in Canada and SSA that fall under the three broad categories described above, and invite selected ones to join for each specific well defined project. In this way the web of alliances created, would support best the general objectives of ACACIA.

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